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ABSTRACT

Two studies were conducted in an effort to see if less skilled readers could be trained to pay closer attention to the hierarchically coherent aspects of text by representing text structures in nodes-relations flowcharts. The subjects were 88 students from two community colleges. A pretest-posttest design with controls was employed. The analysis of data in the first study showed that a significant improvement on the Nelson-Denny Reading Comprehension test scores accompanied an improvement in the quality of posttest text flowcharts produced by experimental students. In the second study, an experimental group of less skilled readers improved significantly more than a comparable control group on the Nelson-Denny Reading Comprehension test. On another comprehension test, designed to measure students' sensitivity to interpropositional relations, experimental students performed significantly better than control students. In addition to the statistical analyses in the second study, samples from experimental-group students' written products were subjected to in-depth analyses. These analyses pointed to qualitative changes in subjects' ability to construct text flowcharting, and supported the quantitative analyses. (RL)

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CENTER FOR THE STUDY OF READING

Technical Report No. 211

FACILITATING READING COMPREHENSION THROUGH FLOWCHARTING

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Abstract

In an effort to train less skilled readers to pay closer attention to hierarchical coherent aspects of text, students were taught to represent text structure in nodes-relations flowcharts. Two training studies were conducted. Subjects were students from two community colleges. A pretest-posttest design with controls was employed. The analysis of data in Study 1 showed that a significant improvement on the Nelson-Denny (1973) Comprehension scores was accompanied by an improvement in the quality of posttest text flowcharts produced by experimental students. In Study 2 an experimental group of less-skilled readers improved significantly more than a comparable control group on the Nelson-Denny Reading Comprehension test. On another comprehension test, designed to measure students' sensitivity to interpropositional relations, experimental students performed significantly better than control students. In addition to the statistical analyses in Study 2, samples from experimental students' written products were subjected to in-depth analyses. These analyses point to qualitative changes in text flowcharting, and support the quantitative analyses.

Facilitating Reading Comprehension through Flowcharting

Knowledge of text structure and text structure markers seem to constitute components of prior knowledge that facilitate reading comprehension. The purpose of the two studies reported in this paper was to examine the instructional potential in training less skilled readers to distinguish content from structure and to represent texts in content-relations flowcharts.

Describing Expository Texts--Distinguishing Structure from Content

The structure of expository texts can be graphically represented in treelike hierarchies. In such hierarchies the nodes represent content units (i.e., propositions, idea units), and the lines connecting them represent the relations of these units to each other (local functions) or to the entire passage (holistic functions). These relations, which will be referred to as Text Unit Functions (TUFs), include such functions as topic sentences and conclusions (at the holistic level), and functions such as causal relations, process descriptions, elaborations, examples, and details (at the local level).

The distinction between local and holistic functions is a relative one. When the hierarchical-functional analysis is applied to a paragraph, the role of a particular sentence and of that paragraph within the larger passage is not taken into account. When larger passages are considered, it seems essential to adopt a more complex notion of the text as consisting

of "hierarchies within hierarchies." Thus, for instance, a sentence which is classified as fulfilling the function of "topic" within the paragraph microstructure (to borrow Kintsch and van Dijk's, 1978, terminology) may be considered as a "detail" within the text macrostructure. Such text unit functions (TUFs) as those suggested above may be used in describing information in paragraphs as well as in larger text units. Thus, for instance, a cause-effect framework may underlie the structure of a complete chapter (e.g., "Causes of the French Revolution"). It may also underlie the relation between two elements within a sentence (e.g., "wind causes waves"). Figures 1 and 2 provide an example of an expository text paragraph and its flowchart representation.

One of the forms of prior knowledge that enables comprehension is knowledge of text structure (see Baker, 1979; Eamon, 1978-79; Marshall & Glock, 1978-79; Meyer, 1975; Meyer, Brandt, & Bluth, Note 1). Skilled readers presumably use this knowledge in systematically applying various skimming strategies (e.g., "here is another example, I am going to skip it"), as well as when carefully reading a text (e.g., "let me read again the description of this process").

The purpose of the present studies was to examine the instructional potential in training less skilled readers to utilize knowledge of text structure in reading. More specifically, in order to train less skilled readers to pay closer attention to structural-cohesive aspects of texts, students from two community colleges were taught to use the TUF repertoire in order to represent in flowcharts both prior knowledge about a

Waves

Waves are caused, as nearly everybody knows, by the wind. Two classes of waves may be distinguished: the long rollers at the coast, and the far more irregular forms of the open sea, where waves of all sizes and types are present. The size and speed of waves depends not only on the wind's speed but on the length of time the wind has been blowing, and the unbroken stretch of water over which it blows as well. Very strong winds tend to beat down the waves' height and to reduce wave speed. On the other hand, less violent but steady winds often produce wave speed greater than that of the wind itself. The average maximum wave height is about 36 feet, although occasional higher waves have been measured.

Figure 1. "What causes waves?" text.

Figure 2. Sample of hierarchical paragraph analysis of the text in Figure 1.

given topic and the structure of given texts. It was hypothesized that teaching less skilled readers to pay closer attention to text elements and to how the text has modified one's knowledge would result in improvement in reading comprehension.

The rationale for teaching text flowcharting is twofold. First, text flowcharting is seen as having affinity to the manner in which knowledge structures (see J. Anderson, 1976; Smith, 1980; Posner, Note 2) and text structures (see Armbruster & Anderson, 1980; Geva, 1980; Dansereau, Note 3; Schallert, Tierney, & Ulerick, Note 4) are believed to be organized. That is, both knowledge and texts are conceived of as hierarchical networks. Thus, it would seem economical and logical to articulate prior knowledge, as well as one's recognition of text structure, within a hierarchical framework. Such representation might facilitate the recognition that certain concent units or text unit functions are missing or inaccurate. Trabasso (1980) refers to these as "empty slots" and "fuzzy relations," respectively.

Secondly, from an instructional point of view one can hypothesize that the actual process of representing prior knowledge and texts is a facilitative procedure because it forces the student to distinguish function (i.e., structures and relations) from content (i.e., semantic units), (see Rigney & Monroe, Note 5). By attempting to represent knowledge in such a fashion, the learner is encouraged to consider all the elements and to create a coherent representation (see Anderson & Armbruster, 1980).

In other recent studies where a form of graphical representation of texts has been utilized (Armbruster, 1979; Holley, Dansereau, McDonald, Garland, & Collins, Note 6), the focus was on the facilitative nature of "mapping" or "networking" for studying purposes. Holley et al. report on a study in which university students were taught to map texts. This studying technique proved effective in recalling information from the mapped texts. It was especially beneficial for students with lower grade point averages. The study by Armbruster (1979) also showed facilitative effects for mapping as a studying technique for middle school children. Note that in these studies the focus was on using mapping as a studying technique which is just as efficient as such techniques as underlining or notetaking (cf. Anderson & Armbruster, 1980). In the present studies the emphasis was on the effect on comprehension of teaching students to uncover text structure. In other words, it was expected that students would learn to apply a top-down, cyclical, framework-seeking approach when they read a variety of texts.

Conjunctions signal various logical relations that exist between propositions or sets of propositions. The next section offers a brief overview of the way in which conjunctions make explicit text structure.

Conjunctions as Text Structure Markers

Halliday and Hassan (1976) suggest that conjunctions constitute one of the means for achieving cohesion in texts. In other words, conjunctions mark the logical relationship between propositions. Kintsch and van Dijk

(1978) and Crothers (1978) suggest that the relations between propositions in coherent texts may be expressed by such conjunctions as and, but, because, and next.

Indeed, as part of the proliferation of studies on various aspects of texts in recent years came an increase in the number of studies where the effects on comprehension of manipulating conjunctions in texts was measured (see Marshall, 1976; Geva & Tierney, Note 7; Johnston & Pearson, Note 8). The underlying logic in these studies is that: (a) consideration of text structure relations is essential for deep comprehension; (b) conjunctions mark many of the relations embedded within the text hierarchy; (c) if these markers are missing, it is essential to infer them. Hence, one may look for differences between more and less proficient readers in their utilization of such markers and in their tendency to infer such markers when these are not explicit in the text (cf. Marshall, 1976).

The majority of text unit functions are signalled by the use of conjunctions. Thus, for instance, causal relations are typically marked by causal conjunctions (e.g., since, because, due to). The description of a process may often include such temporal interunit links as first, next, and then. Contrastive elaborations may be marked by adversative conjunctions (e.g., however, on the other hand). Additive, listlike elaborations are marked by additive conjunctions such as in addition, likewise, and furthermore. Conclusions are

typically preceded by temporal conjunctions such as in conclusion, or to sum up. Finally, examples are signalled by the additive conjunctions for example and for instance. Notice that there are no specific conjunctions to mark topic sentences, definitions, and details.[1]

In the research reported in the present paper, conjunction use as text structure markers was utilized in two ways. Firstly, it was hypothesized that students' performance on two tests which involved the manipulation of conjunctions would provide an indirect measure of students' sensitivity to text structure. Secondly, as part of the training, students performed various tasks whose purpose was to increase their sensitivity to the logical-structural role of conjunctions in expository texts.

STUDY 1

Study 1 posed three related questions: (a) Can students learn to represent texts in flowcharts? (b) Will the experimental intervention result in reading improvement? (c) How does the experimental intervention compare to the control remedial reading programs on a variety of comprehension measures? A positive answer to the first two questions would lend support to the theoretical notion that skilled readers process texts hierarchically, and to the argument that flowcharting enables the application of such strategies by less-skilled readers. The third question has to do with experimental-control differences.

Method

Subjects

Subjects were 48 first-year community college students, enrolled in an English course. All students took the English course as part of their first-year college curriculum requirements. The experimental intervention took place during the period allocated by the course instructor towards improving reading comprehension.[2] Students could enroll in one of two classes taught by the same instructor during the second semester. Students chose the class on the basis of convenience. Both classes were heterogeneous in terms of students' abilities[3] and in terms of the program they were in (e.g., management, design). Students within each class were randomly assigned to an experimental or a control group.

Design

A pretest-posttest design with controls was used. Each of the two classes was divided into an experimental and a control group. The researcher taught separately the experimental groups using the experimental materials. The regular college teacher taught the control groups. It was impossible to have an additional no-treatment control group. Therefore, the results of a reading improvement study by Rayborn and Thompson (1975) will serve as a basis for that comparison. In that study, the Nelson-Denny Reading Comprehension Test was used as a comprehension measure, and a no-treatment control group was available.[4]

Materials

Teaching materials. The teaching materials for the experimental classes utilized expository factual texts from a variety of college textbooks and professional journals. Texts ranged in length from a single paragraph to one page. The guiding rationale in designing the tasks was that students should first become familiar with various TUFs within single paragraphs. During this phase students engaged in tasks such as underlining a text segment which fulfilled a certain function (e.g., elaboration) as well as in tasks where they were asked to identify the function of a given sentence (e.g., topic) and predict the function and content of the following text segment (e.g., cause-effect). A considerable number of tasks focused on the identification of cause-effect and process descriptions in texts. The identification of conjunctions and the realization of their logical-structural implications was dealt with next. A typical task required students to identify the causal conjunctions in a paragraph and represent in a cause $\longrightarrow$ effect frame the relevant text elements. Towards the end of the training period, students engaged in tasks where complete passages had to be represented in nodes-relations flowcharts.

Control students were exposed to individualized teaching, transmitted through tapes. During each session students performed some speed reading related tasks transmitted through tape. These tasks involved skimming and scanning, surveying, and looking for key words. One tape

dealt with identifying conjunctions in texts. During each session students also worked with a set of Reading for Understanding (SRA) (1971) cards. Students could progress through the course program at their own pace. This system enabled the college teacher to handle heterogeneous student ability. His role was mainly one of management (for more details, see Geva, 1980).

Testing materials. The test battery consisted of five tests. (a) The Nelson-Denny Reading Comprehension Test (1973) (Forms A, B) is a standard text used in most community colleges as a measure of reading comprehension; there are 36 items in each form. (b) The Watson-Glaser Critical Thinking Appraisal (1964) (Forms, YM, ZM). This test was administered because it seemed to test some of the high-level logical prerequisites involved in reading comprehension. In an effort to limit the amount of testing, only 3 subtests were administered (Inferencing, Interpretation, and Evaluation of Arguments).

The remaining two tests, the Connectives and the Cloze test, were developed in accordance with the rationale that conjunctions signal text structure, and that performance on conjunctions related tasks would provide an indirect measure of student sensitivity to the logical-structural aspects of the texts they read. (c) The Connectives Test (Forms A, B) is a revised version of Robertson (1966). Each form consists of 30 items in which part of a sentence, following a conjunction, has been omitted. Subjects have to choose the correct ending

phrase out of four suggested alternatives. The purpose of administering this test was to find how students can utilize the logical implications of conjunctions, in order to choose a semantically appropriate completion of the sentence. (d) The Cloze Test (Forms A, B) consists of a short expository text ("What a child needs in order to acquire language"; "The learning of function words by young children") out of which all conjunctions have been omitted. Students have to choose the appropriate conjunction out of four suggested alternatives. Each set of alternatives consists of an additive, a temporal, a causal, and an adversative conjunction (see Halliday & Hasan, 1976). There are 14 cloze items in Form A and 22 in Form B. This test is meant to measure students' explicit or implicit realization of intersentential logical relations. The first four tests were administered to all students. For practical reasons, the fifth test, (e) Flowcharting a Complete Paragraph, could be administered as a pretest and posttest only to experimental students. At pretest, students were shown a model of a flowchart representation of a paragraph (see Figures 1 and 2) and were asked to prepare a similar flowchart for another passage ("Types of soil"). As a posttest, experimental students prepared a flowchart representation of another passage, dealing with classical and operant conditioning.

In evaluating these flowcharts, a measure developed in a pilot study was employed. This measure, the ratio of correct TUFs, is

derived by calculating the ratio of correct TUFs represented by each student out of the total number of relations represented by that student (for more details, see Geva, 1980).[5]

Procedure

The first and last weeks out of a seven-week period were devoted to the administration of the test batteries. Tests were administered on two separate days. On the first day all students took the Nelson-Denny Comprehension Test and the Connective Test. The Watson-Glaser Critical Thinking Appraisal and the Cloze Test were given two days later. Instruction took place during the intervening five weeks. Students met for two 2-hour block sessions per week. Flowcharting a text as a pretest was performed during the first session in which experimental students met as a group. Flowcharting a text as a posttest was performed during the last week of the experimental intervention. The administration of the latter test lasted one hour.

Results

Improvement in Flowchart Preparation

In an effort to determine to what extent the flowchart technique is teachable, students' flowchart representations were evaluated twice: once at the beginning of the training program and once at the end. Applying the method described above, the ratio of correct TUFs was used as an index of the relative quality of the flowcharts. Table 1

shows the pretest and posttest means and standard deviations on the Nelson-Denny (ND) and the TUF scores. A *t* test on the difference between the pretest and posttest ratio of correct TUFs has shown that, in spite of the fact that the text used for the posttest was more difficult (classical and operant conditioning) than the text used for the pretest (the effect of soil type on plant growth), a significant improvement occurred, $t(19) = 2.96$, $p < .001$. A *t* test applied to the mean difference between the Nelson-Denny pretest and posttest for these students also pointed to a significant improvement, $t(19) = 4.35$, $p < .0001$.

The Relation between Improvement in Flowchart Preparation and Reading Comprehension

The second question posed by this study focused on the relation between improvement in reading comprehension (as measured by a standardized test) and the quality of text flowcharts (measured by the ratio of correct TUFs). In order to answer this question, a partial correlation between the Nelson-Denny posttest (Form B) and the posttest TUF scores, controlling for the pretest scores on the Nelson-Denny (Form A) as well as the pretest TUF scores, was calculated. This correlation was significant, $r(19) = 0.57$; $p < .01$. In other words, for the majority of students, an improvement in comprehension scores was accompanied by an improvement in the representation of text structure in flowcharts.

Table 1

Pretest and Posttest Means and Standard Deviations for Percent of Correct Functional Relations, and for the Nelson-Denny Reading Test

	Percent of Correct Functional Relations		The Nelson-Denny Test	
	Mean	SD	Mean	SD
Pretest	66.62	20.80	16.65	5.89
Posttest	81.85	17.41	20.23	5.63

Note. (n = 20)

Experimental-Control Difference

Table 2 shows means and standard deviations for the battery of pretests and posttests. Since the class variable yielded no significant main effects or interactions, the results reported in Table 2 were collapsed across classes. As can be seen, in all groups the mean scores on the Nelson-Denny posttest were higher than those on the pretests. There were no significant pretest-posttest differences on the other measures. Likewise, there were no marked differences between the experimental and control groups on these measures.

A 2 x 2 (Class x Treatment) analysis of covariance was applied to each of the dependent (posttest) measures. Students' scores on the Nelson-Denny pretest served as a covariate. These analyses have shown that there were no significant Class x Treatment interactions, nor Class or Treatment main effects on any of the variables. The only significant measure which enabled one to explain the variance was the covariate. The corresponding $F(1,40)$ values for the four analyses were 60.60 ($p < .001$), 4.00 ($p < .05$), 8.433 ($p < .01$), and 6.73 ($p < .01$) for the Nelson-Denny, the Connectives Test, the Watson-Glaser Critical Thinking Appraisal, and the Cloze Test, respectively.

Discussion

The significant change on the TUFs measure shows that students improved their ability to detect and represent the functional relations among text propositions and to realize their role in the overall

Table 2

Means and Standard Deviations of Pre- and Posttest Measures (Study 1)

Groups	Pretests				Posttest			
	Nelson-Denny	Connectives	Watson-Glaser	Cloze[a]	Nelson-Denny	Connectives	Watson-Glaser	Cloze[a]
Experimental (n = 22)								
Mean	16.09	24.91	33.68	82.14	19.50	25.26	31.75	66.73
SD	5.51	3.52	4.30	11.47	5.91	2.58	4.32	12.09
Control (n = 23)								
Mean	17.26	26.77	35.60	79.29	20.08	25.75	32.99	63.80
SD	5.47	2.37	4.15	21.38	5.74	1.77	5.57	12.86
Total	17.28	25.89	35.26	81.64	19.85	25.59	32.57	62.65
	5.93	3.14	4.69	17.26	5.61	2.23	5.02	12.32

[a]Scores for the Cloze Test are in percentages.

paragraph structure. Furthermore, the significant partial correlation between the posttest reading comprehension scores and TUF scores lends support to the argument that those students who improved on one measure also improved on the other. Furthermore, it lends plausibility to the conjecture that the acquisition of a procedure for uncovering text structure facilitated the improvement in reading comprehension. These results are in accord with the findings of studies on the relation between text structure organization and indices of recall and comprehension, where good and poor readers are reported to utilize differentially structural text information (see Alessi, Anderson, & Goetz, 1979; Baker, 1979; Olshavsky, 1976-77; Schwartz, 1979). The significant partial correlation suggests that flowcharting is an indicator of reading comprehension, a possibility that is theoretically and practically intriguing. Neither the experimental nor the control programs focused directly on aspects of critical thinking, as measured by the Watson-Glaser Critical Thinking Appraisal. Therefore, it is perhaps not surprising that no improvement in critical thinking was recorded.

As can be seen from Table 2, the means of both the pretest and the posttest scores on the Connectives Test in all groups was fairly high, indicating that students were performing at almost a ceiling level on both occasions. Consequently, it is possible to conclude that community college students have no apparent difficulties in performing this recognition task.

Whereas the Connectives Test may be considered too easy, the opposite seems to be true for the Conjunctions Cloze Test. Both cloze tests deal with child language. Here students had to consider propositions as well as the logic that might underlie the relations between these propositions, and then had to choose the appropriate conjunction. The mean score in all groups on the posttest measure was lower than in the pretest. Perhaps the heavier loads of psycholinguistic jargon in this text might explain the drop in mean scores. In other words, lack of prior knowledge contributed to its difficulty and to the suppression of any potential experimental-control differences. It is interesting to note that the highest score (95%) was achieved by an experimental student who had some background in psychology.

The analysis of covariance pointed to no experimental-control differences on the Nelson-Denny Reading Test, though a positive and significant change from pretest to posttest was recorded under both conditions. Rayborn and Thompson (1975) found no significant improvement on the Nelson-Denny comprehension scores of undergraduate students who were not exposed to any direct reading improvement intervention during a reading methodology course. This finding suggests that improvement in the present study did not reflect mere test-retest effects.

Thus, if we ask "Which treatment is better in improving reading comprehension (as measured by the Nelson-Denny Reading Test)?" the

answer is both. One could argue that it does not matter which remedial program is being used as long as the students are forced to read more. Such an argument implies that quantity of reading is the variable that affects degree of comprehension, and that in both control and experimental groups, students were reading better merely because they were reading more. Rather than accepting such a superficial explanation, I decided to develop another test which would be more sensitive to the type of comprehension skills taught in the experimental program. This test was added to the battery of posttests used in Study 2.

STUDY 2

The basic question raised in Study 2 was whether teaching students to utilize a repertoire of text unit fractions and to work out text structure through a flowcharting technique would result in qualitative changes in text processing. Such changes, it was hypothesized, would be manifested in higher reading comprehension scores. The purpose of this study was to replicate Study 1 with revised materials and an additional, more refined measure of reading comprehension.

Most researchers and educators would agree that the type of comprehension that is measured by recognition of verbatim information is different from the type measured by paraphrasing or recall of main/subordinate ideas (R. Anderson, 1972). Indeed, Entin and Klare (1980), who had analyzed the comprehension items of the Nelson-Denny Test,

report that comprehension items, and especially those from difficult passages, seemed to be "prior knowledge" items, that is, items which could be answered correctly without reading the text. Many other items seemed to be verbatim items, that is, items in which a relatively superficial scanning for a key word in the text could provide the appropriate answer. In other words, the widely used Nelson-Denny does not measure high level comprehension strategies. The purpose of developing the Connectives and the Conjunctions Cloze Tests was theoretically based. It was assumed that performance on these measures would constitute an indirect measure of the degree to which students notice the logical relations among propositions. However, the hypothesis that experimental students would outperform their control counterparts on these measures was not substantiated. Thus, it was necessary to develop an alternate measure of comprehension that would reflect the type of skills which were taught in the experimental program. The Either-Or Test was developed for this purpose.

Method

Subjects

Subjects were 40 first-year community college students, enrolled in an English course. All students took the course as part of their first-year curriculum requirements. The experimental intervention took place during the period allocated by the course instructor for improving reading skills.[6] One class consisted of students who were classified by the

college as Medium (Med) on the basis of their performance on the California Achievement Test (scores ranged from 130-160). The low class consisted of students whose scores on the California Achievement Test was lower than 130. Within each class level, students were randomly assigned to the experimental or control condition.[7]

Design

A pretest-posttest design with controls was used. The regular college teacher taught the Med and Low control groups, and the researcher taught the corresponding experimental groups.

Materials

Teaching materials. As was the case in Study 1, the texts used for the experimental condition consisted of expository factual materials. Here, too, the program was divided into three main parts: recognition of single TUFs, the utilization of conjunctions as text structure markers and the representation of complete paragraphs in flowcharts. The materials differed from those in Study 1 in the following ways: (a) Texts were more often taken from recent journals in management and engineering. (b) During the course a larger number of tasks required students to state their prior knowledge of a topic and/or predict the content and function of a forthcoming text segment prior to reading the relevant text. (c) Flowcharting was limited to single paragraphs. (d) Towards the end of the course students were given a few tasks where

a paragraph flowchart was presented to them, but the nodes were empty. The content units were presented separately as a scrambled list. The students' task was to insert the content units in their appropriate nodes in the flowchart. In order to succeed, they had to consider such signals as conjunctions and subordinate-superordinate concepts.

Control students were also exposed to group teaching. They performed various skimming and scanning exercises (with less emphasis on speed reading than in the other college). During each session they worked with a set of SRA "Power Building" and "Reading for Understanding" cards. Students could progress through the SRA series at their own speed, but otherwise instruction was conducted on a group basis.

Testing materials. In addition to the tests used in Study 1, the Either-Or Test was administered. It was designed to test the degree to which students notice specific intersentential and interphrase relations while reading (e.g., principle-example; cause-effect). Students read three expository texts, ranging from 180 to 230 words each. After reading each text, they had to answer a set of comprehension questions without looking back at the text. Each choice in the comprehension items mentioned a function the sentences could have filled in the text. Following is an example.

> Text: In normal activities such as walking, running, kneeling, climbing stairs and getting in and out of chairs, the load put on the human knee joint can exceed five times the weight of the body . . .

Students had to choose between the following either/or alternatives:

Item: either - Running, kneeling and climbing stairs are used in the text as examples of activities in which the knee joint is under a lot of stress.

or - Running, kneeling and climbing stairs are mentioned in the text as typical activities that people have problems with in later years.

There were 16 test items in this test, which was administered as a post-test only.

Procedure

The first and last week out of a six-week period were devoted to the administration of the tests, following the same order as described in Study 1. Instruction took place during the intervening four-week period. Students attended four 1-hour sessions per week.

Thus, Study 2 differed from Study 1 in various ways. First, the teaching materials and tasks were modified. Second, whereas control students in Study 1 were exposed to individual teaching, in Study 2 control students were also taught on a group basis. In addition, whereas classes in College 1 were heterogeneous--they were homogeneous in College 2. Furthermore, the time allowed for improving reading skills was five weeks in College 1 but only four in College 2. Finally, the "Either-Or" Comprehension Test was added to the battery of posttests in College 2.

Results

Table 3 shows the means and standard deviations for the battery of pretests and posttests. An examination of the battery of pretest scores shows that the Med grcups performed better than the Low groups on all but the Connectives Test.

As far as the posttests are concerned, there were no marked changes in the mean scores on the Connectives Test, the Watson-Glaser Critical Thinking Appraisal, or the Cloze Test. At both class levels, experimental students achieved higher scores on the Either-Or Test than control students. One can also see that the most pronounced gain on the Nelson-Denny Test occurred in the experimental Low group.

A 2 x 2 (Class Level x Treatment) analysis of variance on the posttest Nelson-Denny Test yielded a significant Class Level x Treatment interaction $F(1,35) = 6.30$, $p < .05$. As can be seen from Figure 3, the mean Nelson-Denny score in the experimental Low group was higher than the corresponding score in the control group. The mean Nelson-Denny score in the Med experimental group was slightly lower than the corresponding score in the control Med group.

The analysis of covariance for the Either-Or Test (using the Nelson-Denny pretest scores as a covariate) yielded a significant treatment main effect, $F(1,35) = 6.19$, $p < .05$. An examination of the regression lines in Figure 4 shows that the difference between experimental and control groups is especially apparent for students with low scores on the covariate. As was the case in Study 1, the analysis of covariance

Table 3

Means and Standard Deviations of Pre- and Posttest Measures in Study 2

(Treatment Within Class Level)

Groups	Pretests				Posttests				
	Nelson-Denny	Connectives	Watson-Glaser	Cloze[a]	Nelson-Denny	Connectives	Watson-Glaser	Cloze[a]	Either-Or
Medium Class									
Experimental (n = 11)									
Mean	16.27	23.18	32.64	72.71	16.27	21.82	32.00	62.82	12.27
SD	2.49	2.99	2.34	11.43	4.38	3.09	5.22	12.50	1.42
Control (n = 10)									
Mean	16.70	23.40	34.60	74.28	18.40	23.10	31.90	57.73	11.00
SD	3.56	2.84	5.34	13.14	4.30	2.23	4.34	14.22	3.25
Low Class									
Experimental (n = 11)									
Mean	12.27	23.09	29.27	64.92	17.00	21.73	29.82	48.36	11.46
SD	3.90	2.54	5.89	11.71	2.53	4.65	2.99	14.41	0.93
Control (n = 8)									
Mean	11.57	21.00	25.86	57.14	13.43	19.71	27.29	48.68	9.62
SD	1.81	4.86	3.76	13.64	2.70	5.50	4.96	11.32	1.06
Totals	14.41	22.82	30.37	68.14	16.51	21.74	30.51	54.90	11.22
	3.79	3.24	5.42	13.50	3.86	3.93	4.56	14.27	2.05

[a]Scores for the Cloze Test are in percentages.

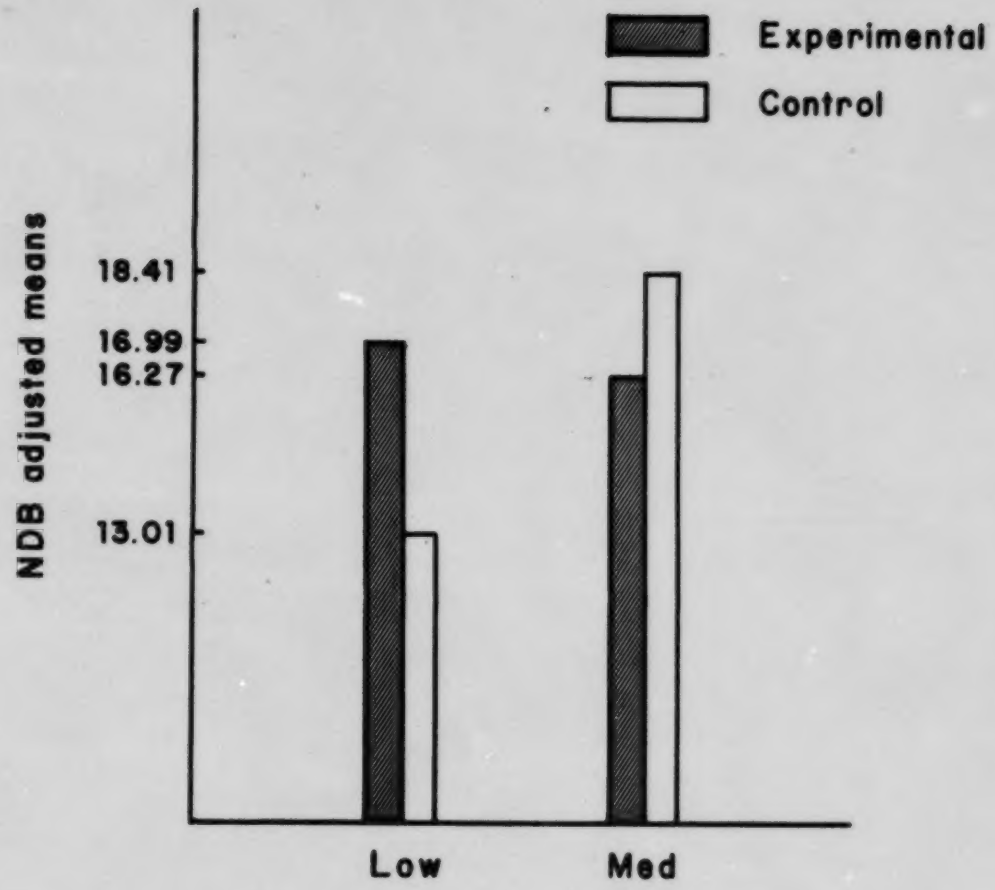


Figure 3. Nelson-Denny posttest adjusted means in experimental and control groups (Study 2).

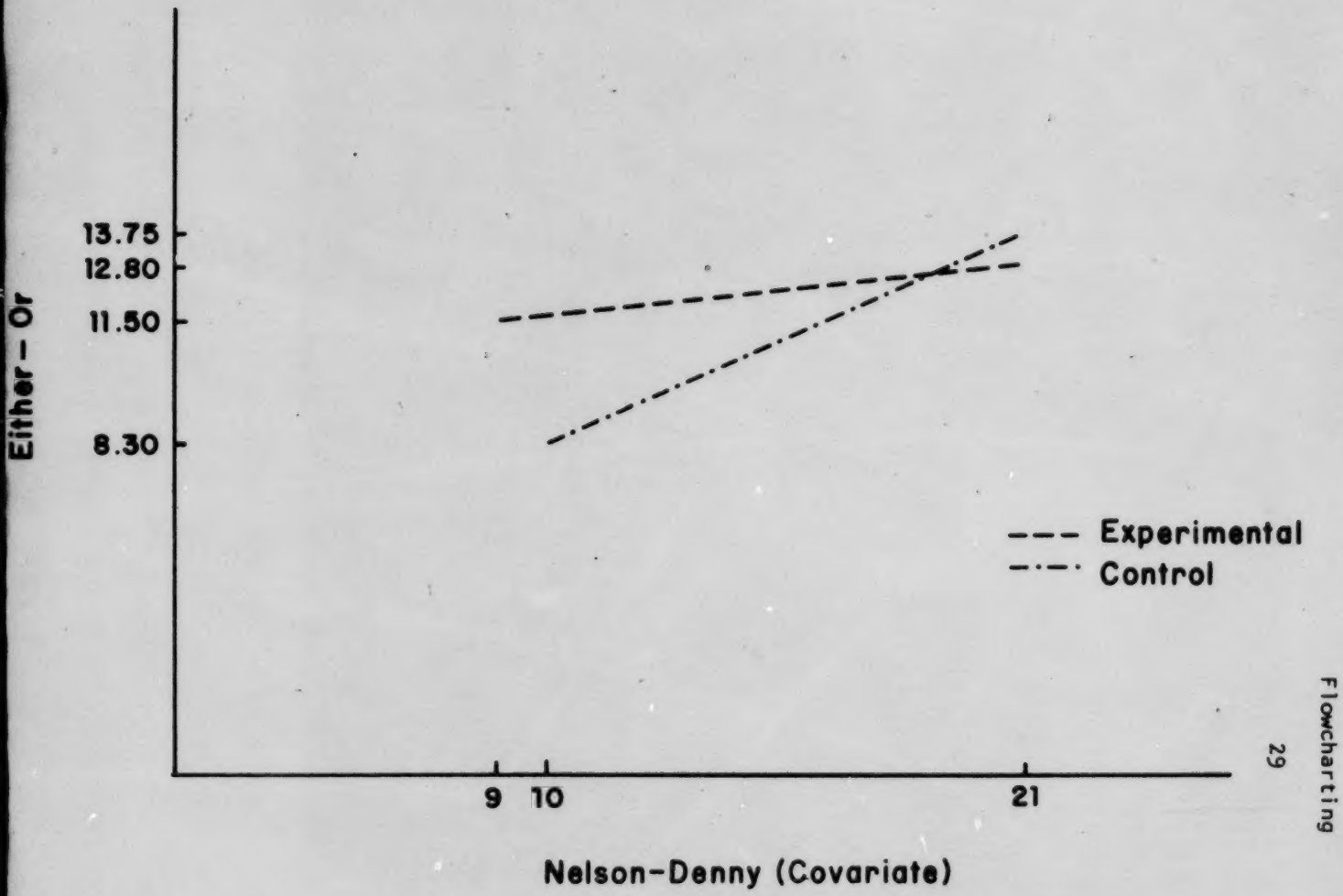


Figure 4. Either-Or regression lines for experimental and control groups (Study 2).

applied to the remaining posttest measures did not yield any interesting results.

Discussion

The analysis of the Nelson-Denny posttest scores indicated that there was a significant Class Level x Treatment interaction, with the Low experimental students benefitting most from the intervention. Factors such as increased proficiency in teaching and the use of modified teaching materials in the experimental groups can partially account for the emergence of experimental-control differences in Study 2, but they cannot account for the Class Level x Treatment interaction. An additional factor, i.e., that groups in this study were homogeneous, should also be taken into account. When a whole group has difficulty with certain tasks, the teacher can perhaps be more perceptive and efficient in dealing with it than in the case where some good students fulfill the teacher's expectations and the teacher assumes that everybody understands.

In addition, however, it seems theoretically valid to argue that at the onset of the intervention, less skilled readers did not process texts hierarchically. The experimental treatment provided Low students with skills for processing texts hierarchically, forcing them to consider how various propositions were interrelated. This qualitative change is suggested both from the results of the analysis of the Nelson-Denny posttest scores and from an examination of students'

written products throughout the course. (See next section for a detailed account of the latter.) Presumably, Med students already had at least an implicit knowledge of text components before the experimental intervention. That is, for them this program was fairly redundant as a means of improving reading comprehension (though they could still benefit from flowcharting when it is used for studying purposes). Holley et al. (Note 6), also reported that teaching mapping as a studying technique was especially useful for low GPA students.

Whereas the Nelson-Denny is a standardized reading comprehension test, the Either-Or was meant to measure the degree to which students notice specific structural interrelations in a less constrained reading comprehension test. The results have shown that the experimental and control groups were significantly different from each other on this measure. Both Low and Med experimental students performed well on the test. In the control group there was a positive relation between a student's score on the covariate and his/her score on the Either-Or. The fact that Low experimental students were performing as well as Med students seems to support the argument made above, namely, that the experimental intervention was especially successful with Low students, because these students were deficient in the cognitive strategies required for processing texts beyond simple decoding and noticing sentence boundaries. Furthermore, the fact that Med control students had no difficulty with these items is

another indicator that good readers have at least an implicit knowledge of these concepts. They can apply it in reading even if they are not taught explicitly to do so.

Bereiter and Scardamalia (in press) argue that the success of teaching high-level strategies should not be evaluated only on the basis of how well the learner performs following intervention, but also on the basis of what it is that the learner does differently. In other words, one should look at the qualitative changes that take place following intervention. Accordingly, samples from students' ongoing written products were analyzed. The purpose of this qualitative analysis was to uncover typical text-structure-related strategies used by students during the intervention. The next section deals with this issue.

THE ANALYSIS OF STUDENTS' ONGOING WRITTEN PRODUCTS

The purpose of teaching flowcharting was to facilitate the iterative application of the following set of strategies: (a) uncover text structure; (b) utilize structural markers when available; (c) articulate prior knowledge before reading; (d) attempt to predict the content and function of the forthcoming text; (e) compare prediction and articulation of prior knowledge against actual text.

During training, students performed various tasks which were designed to encourage the use of these strategies. In this part, samples from students' written products will be analyzed. An attempt

will be made to (a) highlight typical tasks designed to practice these strategies and (b) point out the facilitative potential of the flowcharting technique in executing such strategies.

The task of teaching students to uncover text structure was applied stepwise. Students were first taught to recognize various Text Unit Functions (TUFs) in isolation. Students had no problems in recognizing various TUFs under highly salient conditions (i.e., identifying a single TUF in simple short paragraphs). Yet, when the task required students to coordinate the relations among various text components, less skilled readers seemed to experience various difficulties. Those difficulties will become apparent from the analysis of student tasks in the following sections.

Method-Selection of Materials for Analysis

The various tasks performed by experimental students resulted in the accumulation of approximately 50 pages for each student. A close analysis of all this information for all experimental students would be an insurmountable task. Since the statistical analyses have indicated that the Low group in Study 2 benefitted most from the intervention program, students' written products from this group were chosen for the in-depth, qualitative analysis. The analyses which appear in this paper represent only a sample of such detailed analyses.[8] In order that convenience of reference to each flowchart might be enhanced, nodes were serially numbered. In almost each section a

reference is made to Paul's performance. Paul was a student in the Med group. The analysis of his protocols will serve as a reference norm against which other protocols can be compared. His protocols were chosen for this purpose because they seem to represent a close approximation to "schooled" performance.

Results--In-Depth Analyses

The Order-of-Mention Pitfall in Causality

The problem in coordinating text components was reflected, for instance, in what was referred to as "the order of mention pitfall" in causality. That is, causal phenomena or processes occur linearly in terms of a time dimension. Yet a prerequisite for an accurate representation of the causal elements mentioned in a text is the knowledge that order of mention does not necessarily reflect the nature of the relations among these elements in the physical world. Students were advised to utilize causal conjunctions (because, since) and causal verbs (produce, cause) as cues to underlying causal relations in texts. As we shall see, some readers followed a rigid linear strategy in untangling causal text elements.

Students performed a series of tasks similar to the one reported below during the third week of training. At that time the role of conjunctions in marking text structure was dealt with. The task revolving around the text in Figure 5 required students to (a) identify causal conjunctions and (b) represent the elements that are related

It is frequently necessary to distinguish between dominance--one individual intimidating or threatening another--and leadership--one individual directing the group. Among red deer the dominance shown by males during the breeding season is vastly different from the leadership by the older females who are out ahead of the group and determine its direction without the use of force. Describing a study of goats that showed that being dominant did not help an animal become a leader and vice versa, Scott hypothesized that leadership and dominance behavior are learned separately. Occasionally they may conflict, since one depends upon punishment and the other on reward. However, for the most part, leadership and dominance are closely related. Due to this connection, and also to the greater visibility of the dominant patients, nurses were more likely to ask the dominant patients to lead the group in activities--take them out for walks or to the lunchroom. This attention from the staff reinforced the dominant patient's leadership role since she could issue directives to the other patients with the power of the staff behind her.

Figure 5. Text on "Dominance and leadership."

causally. (They were told explicitly that the arrow should point to the effect.) Students could perform the first part quite well. They had considerable difficulties with the second.

Figure 6 shows a typical Low student product. Gordon's first sequence expresses a causal relation which distorts the text. He takes the lexical item conflict and, through the conjunction since, connects it to the following phrase (depends upon punishment), implying that "conflict" is the cause. In fact, the "conflict" is a result of "depends upon punishment." Notice also that Gordon ignores the second component of this conflict (i.e., "and the other on reward"), which is not immediately adjacent to the conjunction since. In the second sequence, Gordon inaccurately represents another relation because he fails to trace back the referent in This (connection) to the just mentioned leadership and dominance. According to the text, the close relation between leadership and dominance and the visibility of dominant patients (cause) affected the nurses' choice of group leaders (effect). Clearly, this relation is not represented in Sequence 2. In the last sequence, Gordon follows an order-of-mention strategy in relating phrases that precede and follow the conjunction since. Here again, Gordon does not reverse the order of mention in the text in order to uncover the intended meaning.

Paul's performance (Figure 7), on the other hand, reflects an attempt to work out and interrelate text segments. He distinguishes

1.	Conflict	since →	depends on punishment
2.	Lead group activities	due to →	dominant patients
3.	Dominant patient leadership role	since →	power of staff behind her

Figure 6. Exposing causal relations (Gordon).

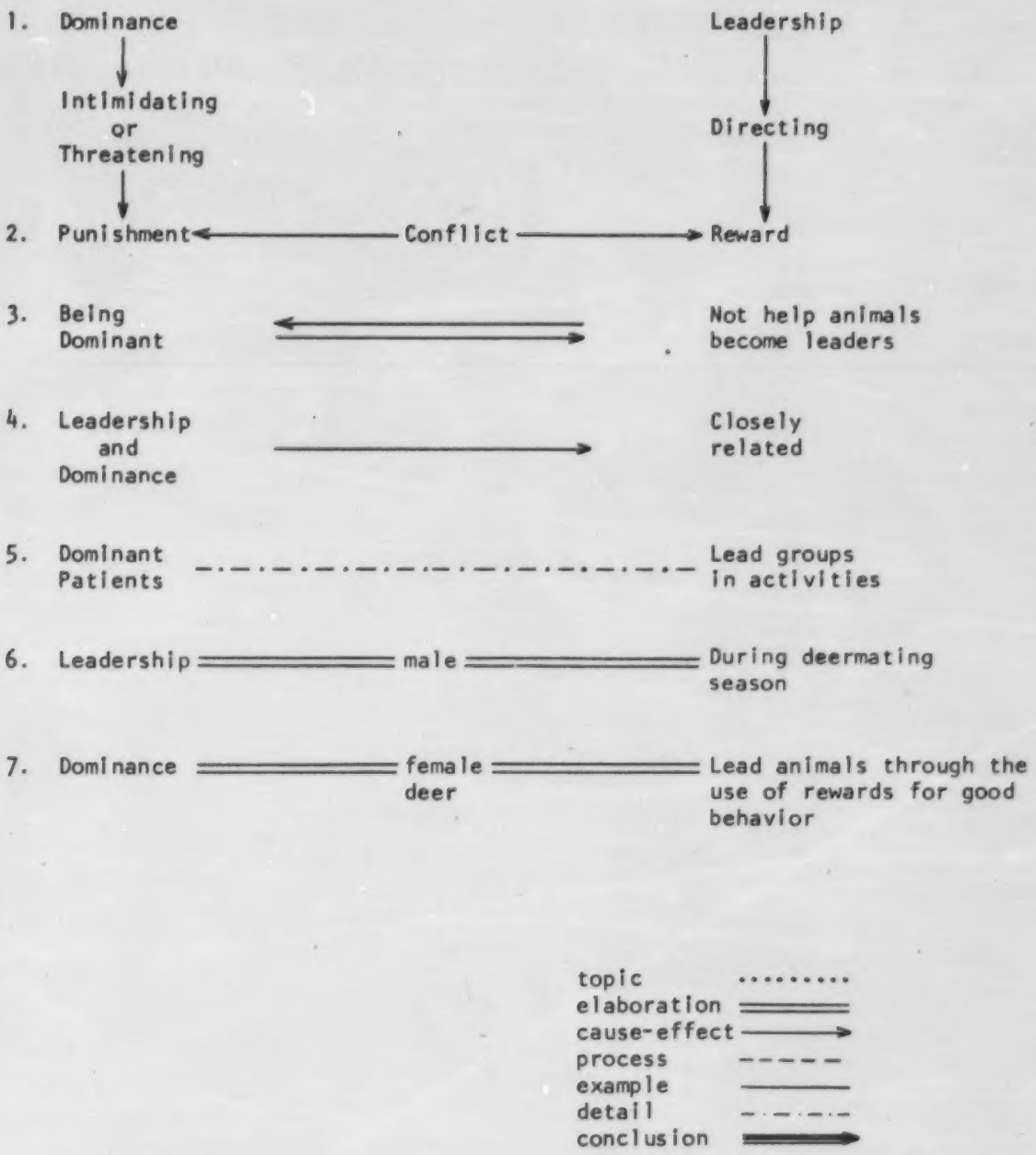


Figure 7. Exposing causal relations (Paul).

the link between dominance, threat, and punishment from the one between leadership, direction, and reward (Sequence 1). In doing that, he uses propositions from the first and fourth sentences in the passage. Note also that the connection between punishment and dominance, leadership and reward (Sequence 2) can be worked out only if the reader remembers, or goes back to check on, what is meant by the first and second mention of one in the fourth sentence. In the fourth sequence Paul shows that leadership and dominance are related. Then, in the fifth sequence, he expresses the link between "dominant patients" and "group leadership" as an example of the principle expressed in the third sequence. In the sixth and seventh sequences, Paul goes back to the second sentence and expresses as elaborations the association between dominance and leadership patterns in red deer. (Paul has reversed the sexes in doing that.) In the seventh sequence he applies the result of his systematic analysis in the first sequence and infers that female deer learn to lead "through use of reward for good behavior." This analysis shows that Paul has in his repertoire skills for identifying basic meaningful units, for overcoming order of mention as a sole cue for relating causal elements, for interrelating propositions that are not adjacent, and for inferring relations that are not stated explicitly in the text.

General recommendations may be drawn on the basis of the analysis of these partial flowcharts. These can be formulated as a list of

specific procedural steps that students can apply when reading and studying texts that deal with causality:

1. A causal conjunction indicates causal relations; try to isolate the causal elements around it.
2. Order of mention may be misleading; try to find the intended order of relations by asking "What is the cause?" "What is the effect?"
3. Draw the elements and mark the relations between them. (The arrow points to the effect.)
4. Paraphrase the relations expressed in your representation. Ask yourself: "Does it make sense?"

Understanding Models

The difficulty students had in coordinating text components was reflected in yet another task. Following the discussion of simple examples, the concept of models was introduced and discussed. Students were told that models are a "special kind of an example" which may be useful because one can see the similarities between properties of the familiar model and its referent. In this activity, which took place towards the end of the second week of intervention, students were given a passage which shows how the phenomenon of sea waves breaking against pillars serves as a model for understanding why the sky looks blue.

In this passage the author first describes waves that strike against iron columns of a pier: The large waves reunite behind the

pier, while the short ones are reflected back and scattered. The author then states that the waves/pillars example is a "working model of the way in which sunlight struggles through the earth's atmosphere." The author continues by showing the correspondence between the "columns of the pier" and particles in the atmosphere, and between the waves of the sea and sunlight waves. He points out that the red long waves parallel the long sea waves, and the short, blue light waves parallel the short sea waves. After a description of the blue light waves being scattered by the dust particles, he concludes: "And that is why the sky looks blue."

Students were required to read the text and to (a) draw two parallel representations, one describing the "waves/pier" model, and the other depicting the light phenomenon, and (b) state what was the phenomenon that the author had tried to explain in that text.

A glimpse at Figure 8 is enough to show that Jim failed to represent accurately the parallel between the model and its referent. The left branch includes information only with regard to "short waves." The branch on the right is much longer and here, too, there is no attempt to represent hierarchically the effect of atmosphere particles on short and long light waves. Jim's linear flowchart analysis, which fails to express clearly the parallel between the model and the phenomenon the author attempted to explain, is coupled with an inaccurate articulation of the topic of the passage ("a struggle").

Figure 8. Jim's flowcharts comparing the sea-waves model to sunlight waves.

On the other hand, Paul's articulation of the topic of the passage is clear ("How come we see the sky as in blue colour?"). This is coupled with parallel flowcharts (see Figure 9) that express explicitly the differential effects of obstacles on long and short waves. Paul deals with the elaboration on "obstacles" in atmosphere by representing it in Node 10 as details extending from Node 9. The structure of Nodes 1-5, which describe the sea waves model, is paralleled to that of Nodes 9 and 11-14, where the light waves are described.

In general, it was possible to show that those students whose graphic representations of the two phenomena had parallel structures could also articulate the topic of the passage clearly. Those students whose flowcharts seemed to follow a linear, nonhierarchical procedure and failed to produce parallel representations also failed to articulate the topic clearly.

Seeing Texts as Hierarchies within Hierarchies

Problems that less skilled readers have in coordinating information was also apparent in tasks where flowcharting was not required. In one task students were given an article from Time magazine dealing with legal insurance. They were asked to point to the three most important and least important sentences in it. Students were also asked to explain the reasons for their particular choices. This exercise required students to judge the importance or negligibility of information with regard to the global passage framework.

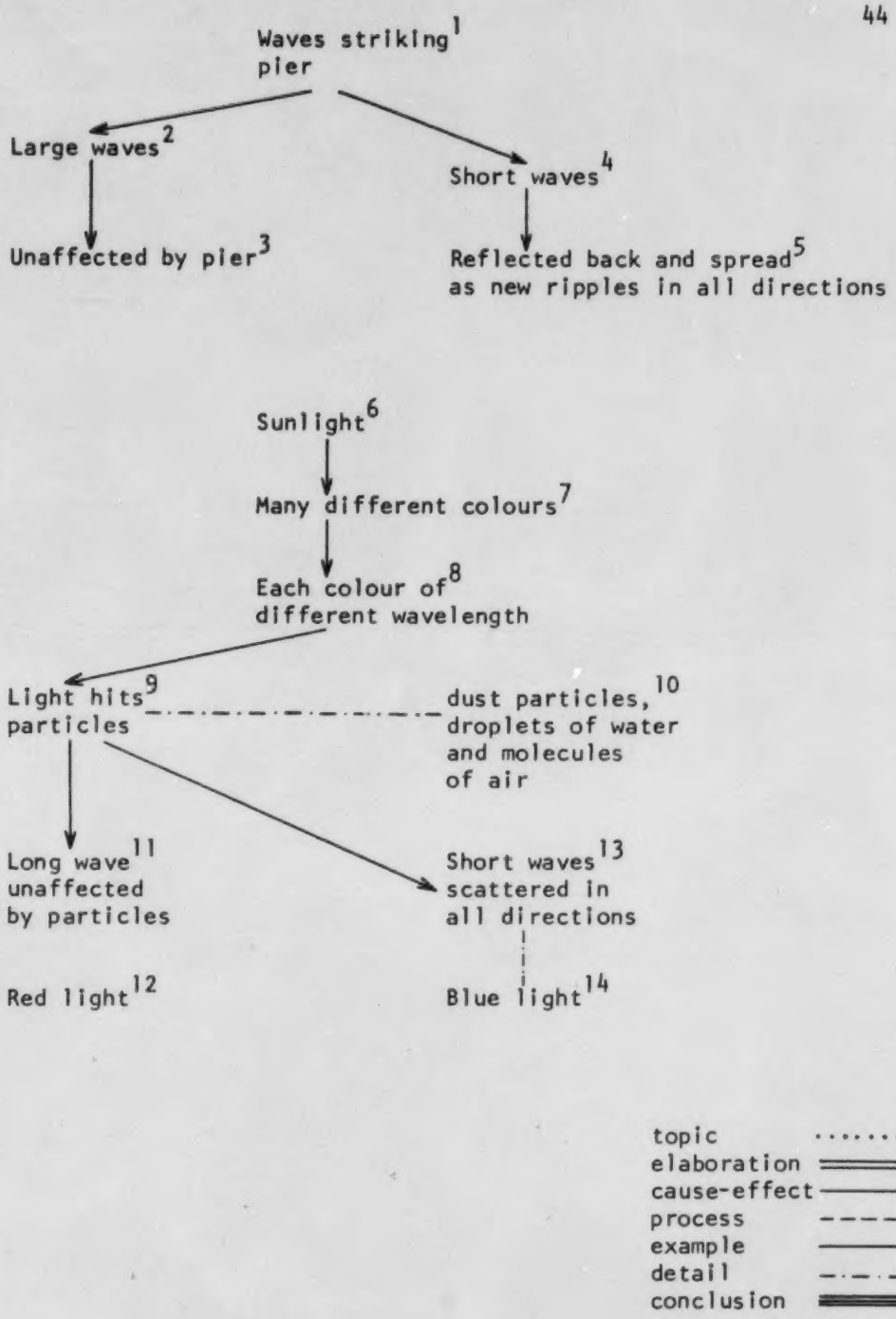


Figure 9. Paul's flowchart comparing the sea-waves model to sunlight waves.

Students unanimously chose details as least important. Less skilled (Low) readers, however, considered important (i.e., "topic") sentences only within the paragraph framework. They did not spontaneously entertain the notion that paragraph topics may fulfill differential functions within the passage macrostructure (e.g., "conclusion," "elaboration"). Also it seemed that the less skilled readers were utilizing an "initial paragraph position--general statement" strategy to decide what was important. This strategy has its drawbacks since "important" sentences do not necessarily appear at the beginning of paragraphs.

Articulating Prior Knowledge

In accordance with the notion that the articulation of prior knowledge and expectations about the forthcoming text are related cognitive strategies that engage the reader in active interaction with the text, several tasks were designed to practice these skills. The following task was performed at the beginning of the third week of the intervention, succeeding practice with single text unit functions. Students were asked to chart information they already had at that time about the topic "devaluation of dollar causing problems in imported car sales." After having articulated their knowledge of this topic, they read a newspaper article about this topic.

The first paragraph in the article explains the relation between the "falling dollar and rising yen" and a rise of 33% in the price

of "Japanese imports in Canada." The following paragraphs provide numerous details about rising car prices and information about sales of Honda and Toyota cars in Canada. The article concludes by mentioning the need to change marketing strategies "away from the low cost aspect to one emphasizing durability, reliability and fuel economy." The topic indicates clearly that a causal analysis is expected.

Figure 10 provides an example of typical performance. Henry's flowchart maintains the topic. He has realized that the topic implies a depiction of a process, and has expressed relevant knowledge about it. For instance, he paraphrases "problems in imported car sales" as "less sell," and "devaluation of dollar" to "dollar ups." Thus, even though he does not provide any new information beyond that which is given in the topic, his paraphrasing indicates that he does not mechanically apply an order-of-mention strategy when he attempts to explain the process. Note that Henry includes only a process analysis without mentioning any relevant examples or details that might, in fact, be part of his current knowledge.

Unlike Henry, who has limited himself to a process description, Paul's representation (Figure 11) includes additional TUFs. Paul's flowchart clearly maintains the topic. In the second node, which is marked as an elaboration of the first node, he explains what the term devaluation means. Then he shows how buying foreign cars was

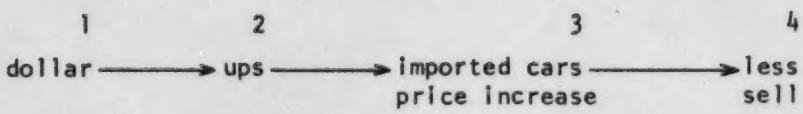
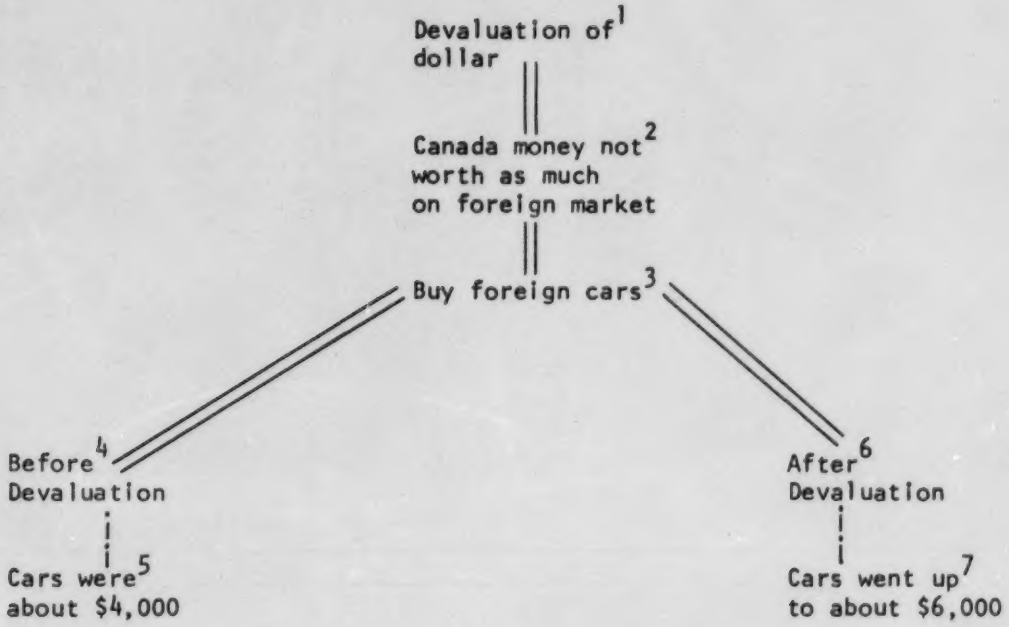


Figure 10. Previous knowledge Henry has about "Devaluation of dollar causing problems in imported car sales."


Devaluation of dollar 1
Canada money not worth as much on foreign market 2
Buy foreign cars 3
Before Devaluation 4
Cars were about $4,000 5
After Devaluation 6
Cars went up to about $6,000 7

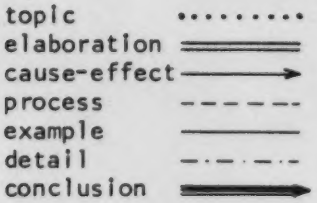


Figure 11. Previous knowledge Paul has about "Devaluation of dollar causing problems in imported car sales."

affected, by giving examples of car prices before and after the devaluation.

Following the flowchart exercise, students were asked to read the actual article and indicate the function (i.e., type) and content of information which was new to them. All students indicated that new information consisted of details.

The foregoing analysis suggests that tasks where students articulate what they know about a topic prior to reading and then label the function and content of text information that is new, have an instructional potential. This may be so because articulating what one knows and then labeling the function and content of what seems new is a process that involves active and systematic interaction with the text.

Predicting Information

In another group of tasks designed to increase student sensitivity to text structure cues, students were given unfinished paragraphs and were asked to predict the function and possible content of subsequent (deleted) sentences. These exercises were presented at the end of the course, after all text unit functions had been taught. Following are examples of answers provided by three students in one such exercise.

The paragraph given to students provides two clear structural cues: It starts by stating that "two modes of portable electricity

exist," and continues by stating "firstly, . . ." (emphasis added). Those sentences that depict the second mode of portable electricity were deleted. On the basis of given information, the sensitive reader can form expectations as to the type of information that will occur (i.e., elaboration of both types of portable electricity). Indeed, Scott and Ed noticed these cues, and predicted that the missing text will deal with the second mode of portable electricity.

Ed: "But some day this form of power will be replaced by another source."

Scott: "Secondly, . . ."

Jim, on the other hand, wrote that the text would deal with "portable electricity." In other words, besides the realization that the text discusses portable electricity, either he was not attentive enough to these structural cues, or his knowledge of such cues was not sufficient. In terms of comprehension processes, such a failure might be even more severe if one has to deal with larger texts, where complete paragraphs or sections separate the cues firstly . . ., secondly . . ., and thirdly . . . from each other. In such texts the efficient reader registers this indication of the hierarchical framework, and forms expectations about the type of information that would fill these structural slots.

The analysis of students' performance on this and other similar tasks has shown that less skilled readers can, in fact, form hypotheses regarding the function of such information. Based on the data, it

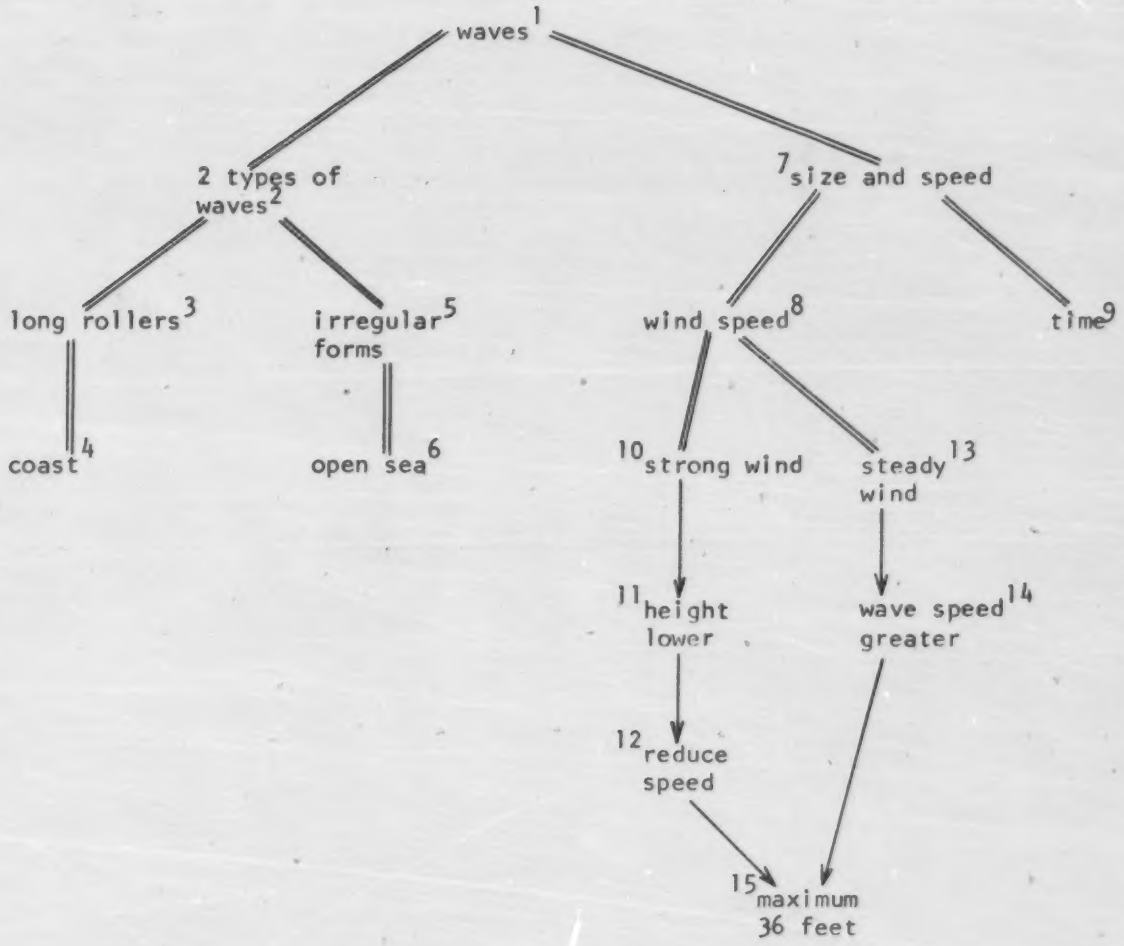
appears that students can be taught directly to utilize structural markers in order to form expectations about the function and content of future text segments, and to piece together meaningful text components into a meaningful whole.[9]

Flowcharting Complete Paragraphs

The foregoing sections dealt with tasks designed to practice, under relatively controlled conditions, skills required in order to bind text components to each other. In this section students' performance under less controlled conditions will be looked at. In order to examine the qualitative changes that took place in students' ability to analyze text structure and represent it in flowcharts, we will look in depth at the flowcharts produced by one student at the beginning and at the end of the course.

At the beginning of the course, students were given an example consisting of a short passage dealing with "the effects of soil types on plant growth," accompanied by a corresponding flowchart representation of this text and a list of text unit functions and their graphic symbols. They were required to use this example as a guide in representing the "wave" passage (see Figure 1).

Figure 12 shows how Bruce approached the task of representing the "wave" passage. In this representation he utilized only two types of functions: elaborations and cause-effect relations. Notice that Bruce did not mark the topic or framework of the passage. He misrepresented



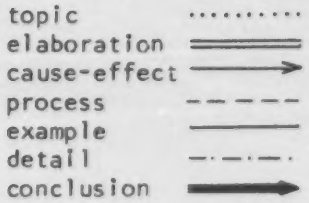


Figure 12. Bruce's representation of the "waves" text (pretest).

the causal relation between Nodes 8-7 and 9-7. In addition, he ignored the third factor, which affects wave height (namely "the stretch of land"). Most important, he failed to notice the interactive relation between "wind strength," "time," and "stretch of land." Finally, he represented Node 15 as a result of Nodes 12 and 14, whereas it seems that the text provides Node 15 as an anecdotal piece of information (i.e., a detail). Yet, in spite of these inaccuracies, Bruce's global representation shows that he has noticed the two main parts of the text: the one describing types of waves, and the one describing the factors that affect wave velocity.

One of the passages which was represented in its entirety by students at the end of the course deals with the fatal effects of carbon monoxide. It describes the process of intoxication in the body and mentions examples of groups that are especially vulnerable to this gas (e.g., babies, people with respiratory and heart problems). It might be expected that readers who attempt to organize information around such a general outline (i.e., the process and the examples) will demonstrate deeper comprehension of the text because text elements will fit together in terms of information, logic, and structure. Students were encouraged to utilize various text unit functions and structural text markers. They were also instructed that in their flowcharts there was no need to follow order of mention in the text.

Figure 13 shows Bruce's attempt to represent this more complex text at the end of the course. In analyzing Bruce's flowchart, we shall first examine his global organization of the text. Bruce has organized the paragraph information in four branches, which all extend from the topic "carbon monoxide" (Node 1). From an examination of the branches one can infer that the two left columns deal with facts related to body processes. The leftmost column is based on information drawn from the first four sentences in the passage, while the adjacent column is based on the very last sentence. This suggests that Bruce was not applying a linear strategy in analyzing the text. The third and fourth columns deal with elaborations on groups that are especially vulnerable to the effects of carbon monoxide (i.e., smokers, infants, people with heart or lung disease). In (implicitly) distinguishing the discussion of the process on the left from the discussion of particular examples on the right, Bruce demonstrates an attempt to represent logically the structure of information in the text. His flowchart does not blindly follow the linear presentation of information in the text.

An examination of internode relations shows that Bruce chose to connect Node 1 to Nodes 2, 8, 11, and 13 with causal notation. Nodes 1 through 3, however, could also be represented as topic arguments. Nodes 11 and 13 could have been represented as fulfilling the example function in the overall framework, while Bruce has represented them

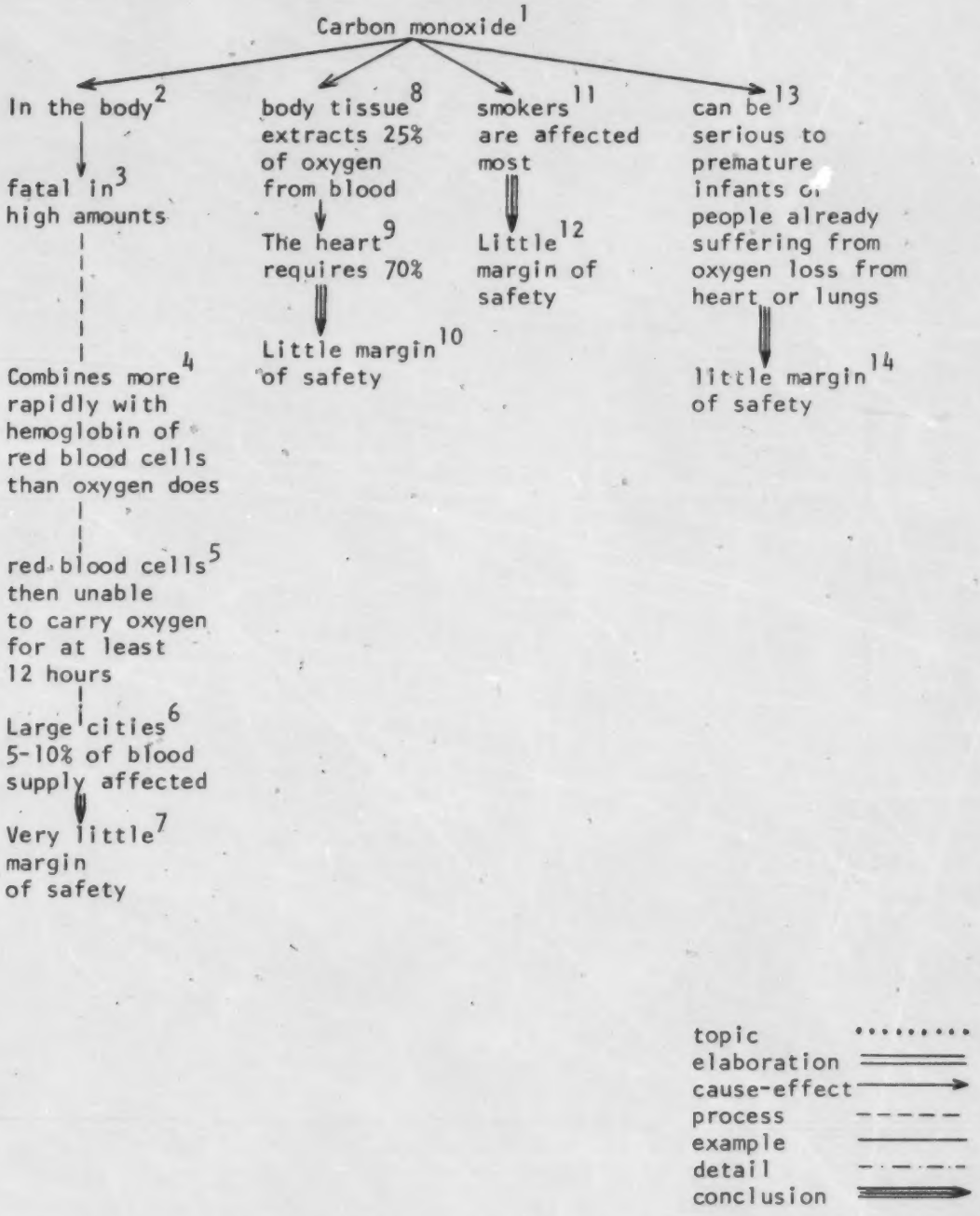

Carbon monoxide 1
In the body 2
fatal in 3 high amounts
Combines more 4 rapidly with hemoglobin of red blood cells than oxygen does
red blood cells 5 then unable to carry oxygen for at least 12 hours
Large cities 6 5-10% of blood supply affected
Very little 7 margin of safety
body tissue 8 extracts 25% of oxygen from blood
The heart 9 requires 70%
Little margin 10 of safety
smokers 11 are affected most
Little 12 margin of safety
can be 13 serious to premature infants or people already suffering from oxygen loss from heart or lungs
little margin 14 of safety
topic
elaboration
cause-effect
process
example
detail
conclusion

Figure 13. Bruce's representation of the text on carbon monoxide (posttest).

as being related causally to Node 1. The internode connections in his flowchart seem to fall in the category of what was defined earlier as "local." That is, Bruce has shown how one factor, carbon monoxide, affects the body, smokers, etc. Alternatively, these could be marked with regard to their "holistic" function, namely, their role in the passage as a whole (e.g., main elaborations, examples). As has been shown above, Bruce's overall organization of the flowchart suggests a realization of these holistic functions in spite of the fact that he does not mark it explicitly.

In the left column Bruce uses the notation for processes well (see Nodes 3 through 5). Nodes 8 and 9 are marked inaccurately as cause and effect, respectively, while the text actually marks the relation between the two with the adversative conjunction <u>although</u>. In this case, then, Bruce is not careful enough in maintaining the correspondence between content and structure. Clearly, the last sentence in the text is a conclusion, marked also by the conjunction <u>so</u>. Bruce expresses it in Node 7 and repeats it in Nodes 10, 12, and 14. In doing that, Bruce attempts to show how each branch by itself leads to the conclusion that carbon monoxide is dangerous. This could be viewed as an intermediate stage of dealing with such concepts as interaction or cumulative effects (i.e., according to the text, carbon monoxide is dangerous, but it is especially dangerous to individuals who have other problems as well). Paraphrasing text propositions (see Nodes 3, 6, 11-12) is another indicator that Bruce has engaged here in deep processing of the text.

To sum up, in spite of certain inaccuracies, Bruce's flowchart reflects an improvement in his ability to read a complex text, distinguish its main constituents, and organize that information in a logical and meaningful way. He has also learned to attend more carefully to various elements in the text and to finer distinctions between text unit functions (e.g., cause-effect vs. process; elaborations vs. details). Finally, it should be pointed out that Bruce's Nelson-Denny reading comprehension score moved upward from the 9th to the 40th percentile. That is, a qualitative change in Bruce's processing of text structure was accompanied by an improvement in his performance on a standardized reading test. (For other similar examples, see Geva, 1980.)

Discussion

The foregoing analysis has focused on various aspects of text flowchart preparation, which, it is argued, are indicative of reading comprehension strategies. The possibility that linear flowchart representation may reflect linear, rather than hierarchical, text processing may be raised. Such a style, typical of Jim's representations, may be characterized as local in that the reader is engaged primarily in the job of parsing the text and relating adjoining elements but does not, at the same time, check whether these elements conform to logic, nor does he attempt to see how the "puzzle pieces" might fit into a more complex global whole (cf. Schwartz, 1979; Spiro, 1979).

One may ask whether readers who display a linear (as contrasted with hierarchical) style of reading could not be characterized as "bottom-up" processors. This suggestion is not relevant since both bottom-up and top-down processing could be characterized as consisting of components that are hierarchically ordered. Thus, whether the skilled reader starts with a schema (top) or with word decoding (bottom) he/she will achieve "deep" comprehension when parts of the text are conceived within a framework. This is similar to the distinction between inductive and deductive reasoning. Whether one starts from instances or from the rule, rule and instance should be finally mapped to each other. Skilled readers can flexibly manipulate their reliance on schemata or word decoding and parsing. If the text is very difficult, they may engage in bottom-up processing, but they still attempt to uncover the whole. Less skilled readers can be taught to look for a fit between text components and text structure. On the other hand, "chronic" linear processing seems to reflect inability to depart from "one element at a time" processing, in spite of prompting.

This foregoing discussion suggests that text flowchart evaluation may be developed into a diagnostic tool. Such a tool could be used to isolate less skilled readers whose text structure perception points to potential for improvement. It could also be used to identify those students who are "one sentence at a time" readers. Such an approach to diagnosing maladaptive reading would be in accord with

Spiro's (1979) warning against treating different causes for poor reading with the same instructional method.

GENERAL DISCUSSION

The first question posed at the onset of the present studies was whether students can be taught to notice text unit functions and to represent texts in flowcharts. The significant improvement on the measures of correct text unit functions in Study 1 provides the basis for a positive answer to this question. The analysis of sample protocols from Study 2 lends further support to this finding. It was shown that there were qualitative changes in the flowcharts produced by students. Thus, we can conclude that students can be taught to recognize global text structure and to identify specific intersentential relations.

The essence of the current studies converged on the notion that flowcharting possesses a facilitative quality. In other words, it was expected that the text flowcharting procedure would enhance reading comprehension. From the analysis of results in Study 1 we know that when the effect of the Nelson-Denny pretest scores and the percent of correct text unit functions on the pretest were partialled out, there was a positive and significant correlation between post-test text flowcharting quality and the posttest reading comprehension scores. That is, those students who expressed text structure more accurately in their flowcharts improved more on the Nelson-Denny test.

These results may be taken as adding weight to the confidence with which text structuring can be seen as reflecting a component in the process of text comprehension.

The Either-Or Test was designed to measure the degree to which students (in Study 2) attended to TUFs while reading. It seems to be a more difficult test, which taps the kind of careful text reading that was taught in the experimental program. Whereas in control groups there was a linear relation between students' score on the covariate (the Nelson-Denny) and their scores on the Either-Or, in experimental groups no such relation existed. Rather, both Low and Med students were performing almost equally well on the test. It is interesting that the Low experimental group, in which the most pronounced improvement on the Nelson-Denny occurred, performed as well as Med experimental and Med control groups on the Either-Or Test. This fact seems to support the argument that learning to recognize text structure enhances more careful reading.

Finally, an in-depth analysis of a sample of student protocols has shown that qualitative changes in text flowcharts was accompanied by a considerable improvement on the Nelson-Denny Test. In general, these results suggest that, indeed, skills associated with recognizing TUFs and text flowcharting were closely related to improvement in reading comprehension.

The next issue to be raised here bears upon the relative efficiency of the experimental program as compared to other remedial reading

techniques. The analyses of covariance in Study 1 showed that there were no experimental-control differences on any of the simple comprehension measures. In Study 2, however, where classes were homogeneous, an Aptitude x Treatment interaction was obtained on the Nelson-Denny Test. Low experimental students benefitted from the program more than Low control students, whereas Med experimental students did not change their comprehension scores. In addition, students in the experimental groups performed significantly better on the Either-Or Test.

These results support the theoretical notion that when there is a deficit in top-down strategies, providing students with a repertoire of TUFs enhances comprehension. When such a repertoire is already available (in a tacit or explicit form), explicit training in the utilization of TUFs cannot be expected to improve reading comprehension. Therefore, it is probably not surprising that the experimental intervention did not yield improvement in the Med group (while there was some improvement in the Med control group). The validity of this interpretation is upheld by the results of a related study reported by Holley et al. (Note 6). These researchers reported that students with low grade point average scores benefitted most from a training program in which they learned to use networking as an aid to studying.

The tasks designed for the experimental program required less skilled readers to map into a content/function framework texts,

prior knowledge, and anticipatory schemata. They had to consider various elements within a cohesive and meaningful framework. The analysis of student products showed that, indeed, students learned to utilize explicit structural markers as well as to attend to the content and structure of the given text, and to generate endings (e.g., conclusions, elaborations). At the end of the course, students' repertoire of TUFs had increased. This was manifested in the variety of TUFs utilized in their flowcharts. It was also manifested in the overall organization of their flowcharts. In other words, they were better able to uncover text structure.

The majority of studies in this area report that less skilled (or younger) readers fail to recognize and/or to consider text structure. This failure is observed, for instance, in their recall of passages where the existence of structural markers is manipulated or where important or unimportant information is presented with or without coherence. Here it was shown that by teaching less skilled readers to search for text structure and to recognize the various components of text structure, they improved their reading strategies. In other words, the present findings suggest that when such strategies are not activated spontaneously, it is possible to teach top-level strategies, and that these strategies transfer to other reading tasks.

The research reported in this paper focused mainly on the analysis of text structure at the paragraph level. Tools for describing the

structure of longer passages need to be developed, coupled with training studies where students will be taught to perceive expository texts as complex hierarchies.

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Footnotes

The studies described in this article are based on research reported in the author's doctoral dissertation (Geva, 1980).

[1]Presumably readers can capitalize on sentence structure and the prevalence of superordinate lexical items in order to recognize topic sentences. Definitions usually take the form "'a' is defined as . . ." Finally, details may be recognized by the relative specificity of the lexical items.

[2]Other parts of the course focused on English grammar and the analysis of some literary works.

[3]Students' scores on the Nelson-Denny comprehension pretest ranged from the 8th to the 96th percentile (using Grade 12 norms).

[4]The Rayborn and Thompson study's purpose was to investigate the possibility that students who, as part of their pre-teaching training, take a reading methodology course would show incidental learning and transfer to their own reading skills. Alternate forms of the Nelson-Denny Reading Test were administered to 183 students as a pretest, and at the end of the semester as a posttest.

[5]A problem with allowing the number of relations to fluctuate is that students may choose to represent only high-level information. In such cases a person's ratio may be very high in spite of the fact that he/she has attempted to deal with very few text elements. It is possible to minimize this problem by either requiring subjects to represent all text elements, or by suggesting an acceptable range.

[6]Other parts of the course involved English grammar, reading a novel, and commercial writing (e.g., writing a letter of application).

[7]Students' scores on the Nelson-Denny pretest ranged from the 9th percentile in the Low class to the 64th percentile in the Med class.

[8]For additional in-depth analyses see Geva (1980).

[9]Scott's Nelson-Denny reading score improved from the 12th percentile to the 42nd percentile; Ed's scores improved from the 34th percentile to the 42nd percentile; Jim's score improved from the 9th to the 32nd percentile; Paul's scores also improved from the 30th to 54th percentile.

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